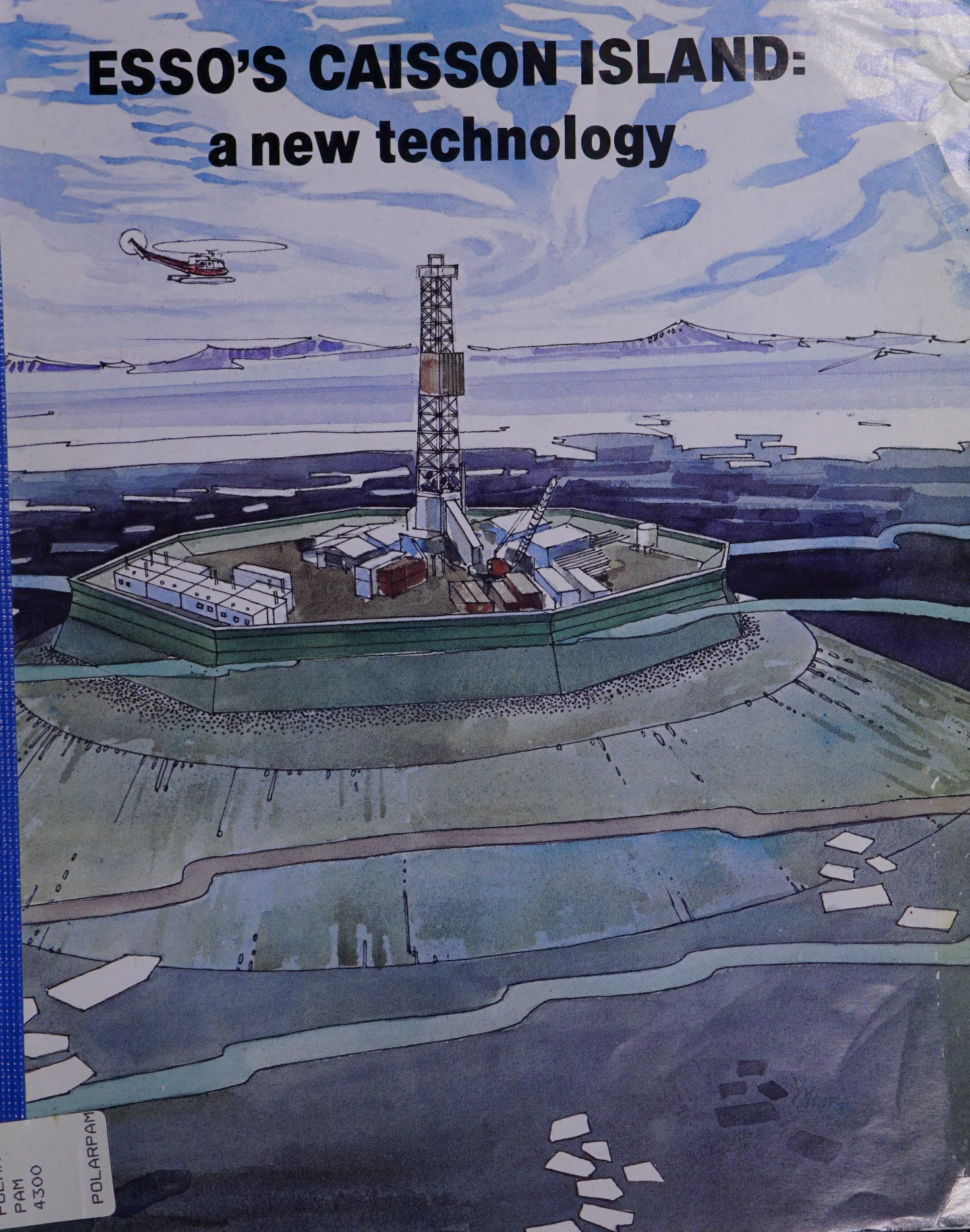
ESSO'S CAISSON ISLAND: a new technology



A DOUGHNUT-SHAPED TECHNOLOGICAL TRIUMPH FOR THE BEAUFORT

BY GERRY KRUK

FOR both Esso Resources and the other Canadian companies involved, the development of a steel caisson retained island (CRI) for Arctic drilling represents a triumph in engineering research. It's a triumph that will extend the company's international reputation as the leader in island design and exploration technology in ice-filled Arctic waters.

"Impressive" and "exciting" are just two adjectives that come to mind when one is given the facts about the massive caisson that Esso Resources will introduce into its Beaufort Sea exploration program in 1983. Weighing 8 000 tonnes, the caisson will resemble an immense steel doughnut more than 100 metres in diameter, with walls 13 metres thick at the base, eight metres thick at the top and 17 metres high. The introduction of the caisson will, by 1983, double the pace of the company's current one-rig Beaufort Sea drilling program, with a commensurate expansion in local northern employment and business benefits. It also will open up for exploration a large high-potential area of the Beaufort Sea, previously inaccessible because of technological and economic constraints.

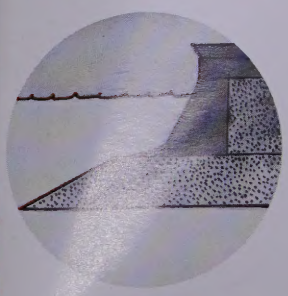
The innovative design of the island dramatically reduces the amount of dredged material needed to build an artificial island. Being maintenance free, it also solves the expensive problem of island erosion in open water. The CRI allows the economic exploration of those vast areas of the western Beaufort Sea lacking the plentiful seabottom sand necessary for onsite dredging of the large "sacrificial-beach" islands used by Esso Resources during the last several years.

Jim Riley, manager of Beaufort projects, is overseeing the final design, construction and installation of the CRI. Riley's involvement in the Beaufort operations dates to 1970, when the company began planning its move into the offshore portion of its acreage. "At that time we investigated a large number of alternative drilling platform concepts that would permit us to drill safely and economically year round in our large, ice-infested Beaufort acreage," Riley says. Although the steel CRI was one of the concepts favored for depths in excess of nine metres, Esso Resources elected to use artificial sand islands, at least initially.

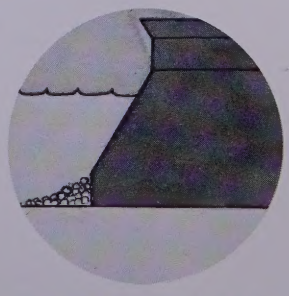
Since the exploration program moved offshore in 1972, the company has used two different types of artificial islands. At first, in very shallow water, "sandbag-retained" islands of silt and sand were used. In waters with good quality seabottom sand and deep enough to permit the operation of the dredge ship *Beaver Mackenzie*, it has proven most economic to construct sacrificial-beach islands. The steel-caisson island ranks as the third technological innovation developed by Esso Resources as a drilling platform capable of operating in thick sea-ice conditions. As one science-fiction movie buff inside the company quipped, the caisson program constituted for Esso Resources a "close encounter of a third kind" with the awesome forces of Beaufort ice.

During the first decade of offshore exploration, the company has drilled many of its major prospects in the eastern Beaufort, where the seabottom sand necessary for the economic construction of sacrificial-beach islands is available in abundance. In such islands, the dredged sand is permitted to take its natural angle of repose. At water level, a gradually sloping 50-metre-wide beach is contoured around the entire island. This beach leads up to a crown or working surface area, about 100 metres in diameter and raised about seven metres above sea level to protect it from wave action. As added slope protection, filter cloth, weighted down with submarine netting and thousands of large sandbags, is applied to the beach and to the steep sides of the working surface.

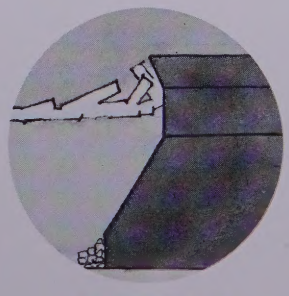
This island design provides a stable year-round drilling platform: in summer, waves dissipate their energy as they roll along the beaches and smash against the sandbags; in winter, the floating ice grounds out on the beaches at some distance from the



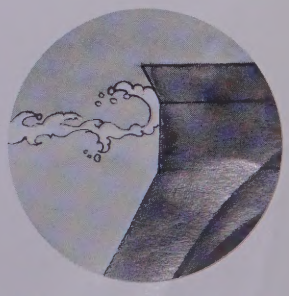
SUBSEA BERM



BERM PROTECTION



ICE DEFENCE



WAVE PROTECTION

island, forming an ice-rubble field that itself acts as a barrier to protect the working surface and its rig. (In the course of a year, however, wave action invariably will erode the beach, giving rise to the term "sacrificial beach.")

Since 1976 Esso Resources has constructed six such sacrificial-beach islands in the eastern Beaufort. The largest and most notable is Issungnak, the site of an encouraging crude-oil and natural-gas discovery in 1980. (In total the company has built 17 artificial islands since moving offshore with its exploration program.) Issungnak, in 20 metres of water, required a staggering five-million cubic metres of seabottom sand, more than $60 million and almost 200 dredging days to construct.

However, plans are now afoot to commence the drilling in 1983 of prospects in the western Beaufort, where the ocean floor is predominantly clay and silt rather than the good quality sand that characterizes the eastern Beaufort. Accordingly, island construction in the western zones would require expensive transportation of the required dredged sand a distance of up to 80 kilometres to the construction site.

Jim Riley explains the problem: "When you have to import your construction material instead of dredging it up at the island site, your laid-down costs for the sand are increased anywhere from 100 to 400 percent, depending upon the distance traveled. Building sacrificial-beach islands in the western Beaufort, because of the large sand volumes required, would therefore not be economic. We had to come up with a different island design that would be as stable as our beach islands, but would require substantially reduced sand volumes and prevent the kind of costly and frustrating erosion that often occurs at sacrificial-beach islands during heavy open-sea conditions. To increase its cost effectiveness, we also wanted the island to be portable and reusable."

In November, 1980, when Esso Resources' exploration department indicated it proposed to drill at the Issigak site in 13 metres of water, about 25 kilometres north of Adgo in the western Beaufort, a field-services department task force quickly determined that the steel CRI was the preferred way to go. Riley emphasizes that the company had been prepared for some time for this step: "The steel caisson is not something we developed recently.

"Between 1975 and 1978, in anticipation of a move into the western Beaufort, Esso Resources mobilized its internal expertise and worked closely with about a dozen Canadian engineering, architectural and scientific consultants in a $2-million program to complete the detailed engineering design and testing of the steel-caisson concept."

The CRI they designed features eight separate 1 000-tonne segments, each 43 metres in length. The caisson walls are constructed at a 60-degree angle to force the sea ice moving against them to crack as they bend against it. As an added safety factor, the walls are designed to be strong and high enough to withstand ice pressures twice the maximum strength anticipated and to hold back the wave action of a Beaufort storm. Each wall segment has ballast tanks to permit flotation as well as electric generating and hydraulic jack equipment to operate the 16 separate 76-millimetre-thick cables (4 876 metres of cable in all) that are used, along with massive steel pins, to lock the eight segments together into one massive integral caisson ring. To provide more space on the working surface, the caisson will contain fuel storage tanks with a total capacity of 45 460 000 litres of diesel fuel. In addition about $1 million worth of sophisticated scientific instrumentation and sensors will be placed in the walls of the caisson to measure ice-load pressures. This data may be helpful in further improving both the structural design and the cost effectiveness of future caissons.

Esso Resources was to sign the construction contract for the caisson by the end of October, 1981, with fabrication scheduled for completion by the summer of 1982. The caisson segments then will be barged to the company's marine base camp at Tuktoyaktuk during July and August of 1982. The timing will be tight: the barge must be at Port Barrow on Alaska's northernmost tip by Aug. 1 to ensure that it doesn't miss the brief open-water season in that area. The segments will be stored at Tuk base during the winter of 1982-83. When open water returns in the summer of 1983, the segments will be assembled into one caisson ring in a protected harbor area and then towed by tugs to the island site at Issigak.

"I'm sure it'll be a remarkable sight," Riley says. "When the caisson is being moved out to Issigak, it will ride 10 metres out of the water and be moving along at about three knots. It'll look like an immense, floating island."

At the drilling site, the caisson ring will be ballasted down nine metres below water level, where it will come to rest on a four-metre-high underwater sand platform, known as a "berm," that will have been constructed in 1982. About 80 000 cubic metres of sand will then be dredged into the interior of the ring to form a 100-metre-diameter working surface onto which the rig, camp and supporting equipment

will be placed. Drilling can then begin and continue over the entire winter. The caisson can be ballasted up and floated to the next drilling location in the summer of 1984.

"In total, despite the 13-metre water depth at Issigak, it will require less than a half-million cubic metres of dredged sand to complete the CRI, at a total cost of about $50 million," Riley points out. "If a sacrificial-beach island were to be constructed there, about two million cubic metres of sand would have to be hauled in, many more days of construction time would be required and at least an additional $25 million spent to complete the island." Riley adds that the reusability and durability of the CRI also improves the cost effectiveness: "The great advantage of the caisson is that, unlike the sand islands, we don't just walk away from it after the drilling is over. We literally take that huge thing with us."

Cliff Kippen, who is Beaufort marine operations coordinator, has been working closely with Riley on the caisson project. With the enthusiasm of an experienced marine captain who knows he's about to be outfitted with a new fleet of seagoing equipment, Kippen explains that ordering the $50-million caisson also will necessitate the spending of about $85 million for additional support vessels.

"Besides a new, more compact drill rig and three-storey camp to go along with the caisson, Esso Resources will be placing orders for a huge 120-metre-by-30-metre barge for transporting the caisson segments to Tuk, three 5 000-horsepower tugs and two 250-tonne cranes for moving equipment from barges onto the island. A large trailing suction hopper dredge for transporting the dredged sand to the construction site also will be ordered, as well as a combination dredge/screed barge for constructing and leveling the underwater berm and for pumping into the caisson the stockpiled sand brought by the hopper dredge. All of these vessels will have ice-reinforced hulls so that, at a minimum, they will be able to move at a steady speed of three knots through one-third-metre thick continuous ice.

"While the company will own the rig, the camp and the caisson itself, we will be entering into long-term leasing agreements for this marine equipment."

In spite of all the economic, technological and energy benefits to Canada resulting from Esso Resources' CRI project, it is probably the men in the field, the men who have battled the Beaufort's fierce winds and waves each fall to complete and maintain the islands, who will most appreciate the caisson's practical benefits. Reflecting on his own many years of fatiguing, nerve-racking work on sand islands, Kippen confesses: "Sometime during a bad Beaufort storm in the fall of 1983, I know I'll particularly enjoy being able to stand on top of our caisson and look down at those huge waves bouncing harmlessly off those steel walls. It'll bring back a lot of memories of bone-wearying hours spent filling sandbags in an effort to save a sand beach."

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GERRY KITCHEN

Cliff Kippen (l.) and Jim Riley with model of caisson-retained island